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09/846,980	04/30/2001	Stephen A. Stockman	M-9635 US	3906

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PATENT LAW GROUP LLP  
2635 NORTH FIRST STREET  
SUITE 223  
SAN JOSE, CA 95134

EXAMINER

SONG, MATTHEW J

ART UNIT	PAPER NUMBER
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1765

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14

Please find below and/or attached an Office communication concerning this application or proceeding.

# Office Action Summary

Application No.

09/846,980

Applicant(s)

STOCKMAN ET AL.

Examiner

Matthew J Song

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

## Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

## Status

- 1) ☒ Responsive to communication(s) filed on 22 May 2003.
- 2a) ☒ This action is **FINAL**. 2b) ☐ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

## Disposition of Claims

- 4) ☒ Claim(s) 1 and 3-60 is/are pending in the application.
- 4a) Of the above claim(s) \_\_\_\_\_ is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.
- 6) ☒ Claim(s) 1 and 3-60 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

## Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on \_\_\_\_\_ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
- 11) ☐ The proposed drawing correction filed on \_\_\_\_\_ is: a) ☐ approved b) ☐ disapproved by the Examiner.  
If approved, corrected drawings are required in reply to this Office action.
- 12) ☐ The oath or declaration is objected to by the Examiner.

## Priority under 35 U.S.C. §§ 119 and 120

- 13) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).  
a) ☐ All b) ☐ Some \* c) ☐ None of:  
1. ☐ Certified copies of the priority documents have been received.  
2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.  
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).  
\* See the attached detailed Office action for a list of the certified copies not received.
- 14) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).  
a) ☐ The translation of the foreign language provisional application has been received.
- 15) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

## Attachment(s)

- 1) ☐ Notice of References Cited (PTO-892)
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) \_\_\_\_\_
- 4) ☐ Interview Summary (PTO-413) Paper No(s) \_\_\_\_\_
- 5) ☐ Notice of Informal Patent Application (PTO-152)
- 6) ☐ Other: \_\_\_\_\_

## DETAILED ACTION

### *Claim Rejections - 35 USC § 103*

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

2. Claims 1, 3-5, 12-30, 31-35 and 42-60 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bour et al. (US 5,926,726) in view of Koike et al. (US 5,811,319) and Furukawa et al (US 6,017,807).

Bour et al. teaches a carrier gas of  $H_2$  is introduced with reaction gases  $NH_3$  and TMGa and impurity gas  $Cp_2Mg$  to a reactor to form a p-type GaN layer at a temperature of  $900^\circ C$  (col 6, 20-26) After formation of the p-type nitride layer the reactant gases are switched out of the reactor and a gas which prevents the decomposition of the III-V layer at such high growth temperatures,  $NH_3$  is added (col 5, ln 60-65 and col 6, ln 31-35). Bour et al also teaches a reactor is cooled down to a temperature where surface decomposition of as-grown p-type GaN layer will not further occur, where upon attainment of the this temperature, the preventer gas,  $NH_3$ , is switched out of the reactor and the remaining cool down occurs in molecular N and acceptor activation is preformed either as the reactor is further cooled or maintained at a temperature of  $600^\circ C$  for 20-40 minutes and during the cool down of the reactor a flow of molecular N,  $N_2$ , is maintained in the reactor. (col 6, ln 40-65). Bour et al also teaches the anneal process is a quasi-in-situ anneal, where the reactor is brought to room temperature prior to annealing (col 2, ln 32-

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45) and that ex-situ post-growth anneals have become a common procedure for laser diode processing (col 2, ln 60-64). Bour et al also teaches acceptor activation is the process of atomic H weakly bonded to Mg or Zn dopant atoms are broken by thermal annealing over a period of time (col 6, 7-15) Bour et al also teaches a device which comprises a sapphire substrate upon which is grown a n-type GaN, doped with Si followed by the growth of an active region and is followed by a p-type GaN layer doped with Mg followed by the growth of a cap layer comprising n-type GaN doped with Si (col 8, ln 46-55) Bour et al also teaches that after growth is complete and the reactor cooldown has been accomplished, the n-type cap layer may be removed by etching and the device processed into an operable laser, this reads on applicant's limitation of forming a light emitting diode. Bour et al also discloses the switchout of the  $\text{NH}_3$  gas is possible at temperatures as high as the lower end of the growth temperature range for GaN that is around  $900^\circ\text{C}$  and maybe higher, with an ambient of  $\text{N}_2$  provided in the reactor, activation may be accomplished in a short period of time (col 7, ln 15-40). Bour et al also teaches after the growth of p-type GaN, all reaction gases are switched out of the reactor including  $\text{NH}_3$  and immediately after growth dimethylhydrazine is pumped into the reactor and the activation process can be carried out during the cooldown of the reactor, this reads on applicant's substantially preventing hydrogen passivation during the entire cooldown process (col 7, ln 55-67 and col 8, ln 1-30).

Bour et al does not teach the causing of the acceptor doped layer to a p-type layer have a conductivity and a hole density between  $3 \times 10^{15} \text{ cm}^{-3}$  and  $1 \times 10^{18} \text{ cm}^{-3}$  after said cool down process.

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In a method of growing p-type gallium nitride, Koike et al. teaches three p-layers of Mg-doped  $\text{Al}_{x1}\text{Ga}_{1-x1}\text{N}$  forms a p-layer (61) which acts as a clad layer having a hole concentrations of  $5 \times 10^{17}/\text{cm}^3$ ,  $5 \times 10^{17}/\text{cm}^3$  and  $2 \times 10^{17}/\text{cm}^3$  and an Mg concentrations of  $1 \times 10^{20}/\text{cm}^3$ ,  $1 \times 10^{20}/\text{cm}^3$  and  $2 \times 10^{20}/\text{cm}^3$ , respectively (col 3, 50-65). Koike also teaches electron rays were uniformly irradiated into the p-layer using a reflective electron beam, where this irradiation changed the p-layer into a p-type conductive semiconductor with a hole concentration of  $5 \times 10^{17}/\text{cm}^3$ ,  $5 \times 10^{17}/\text{cm}^3$  and  $2 \times 10^{17}/\text{cm}^3$  and a resistivity of 0.5 ohm-cm, 0.8 ohm-cm and 1.5 ohm-cm, respectively (col 5, ln 14-26). Koike et al also teaches forming metal electrode, such as nickel or aluminum, are formed on semiconductor devices utilizing GaN group compounds such as AlGaInN after the semiconductor surface is cleaned by wet chemical etching, utilizing a wet chemical etchant such as buffered hydrogen fluoride (col 1, ln 15-30).

It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Bour with Koike's electron beam irradiation because it would have produced p-type conductive semiconductors with low resistivities.

Bour et al also does not teach heating said p-type layer to a third temperature greater than the second temperature and less than 625°C.

In a method of forming a P-type GaN compound, note entire reference, Furukawa et al teaches after a p-type gallium nitride compound semiconductor layers formed by chemical vapor deposition, the p-type gallium nitride layers are thermally annealed at more than 400°C and the p-type impurity can be more effectively activated so that p-type gallium nitride compound semiconductor layers which have fewer crystal defects and lower resistivity can be formed (abstract, col 4, ln 5-67 and col 6, ln 35-60). It would have been obvious to a person of ordinary

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skill in the art at the time of the invention to modify Bour et al with Furukawa et al annealing at a temperature greater than 400°C to form a semiconductor layer which has fewer defects and lower resistivity.

Referring to claim 1 and 31, the combination of Bour et al, Koike et al and Furukawa et al teaches the switchout of  $\text{NH}_3$  is possible at temperatures as high as the lower end of the growth temperature range for GaN and maybe higher with an ambient of  $\text{N}_2$ , this reads on applicant's limitation of preventing additional hydrogen from diffusing into the acceptor doped layer substantially throughout the entire cool down process.

Referring to claim 3 and 33, the combination of Bour et al, Koike et al and Furukawa et al teaches a step (32) where reactant gases are switched out of the reactor and a flow of  $\text{N}_2$  is maintained during the cooldown of the reactor. This reads on applicant's limitation of preventing additional hydrogen from diffusing into said acceptor-doped layer during said cooling process. Also this reads on applicant's limitation of removing hydrogen from said chamber during cool-down process and preventing hydrogen from entering.

Referring to claim 4 and 34, the combination of Bour et al, Koike et al and Furukawa et al teach a cap layer comprising n-type GaN doped with Si, this reads on applicant's limitation of preventing additional hydrogen from diffusing into said acceptor-layer comprising form a n-type semiconductor layer over said acceptor-doped layer prior to said cool-down process.

Referring to claim 5 and 35, the combination of Bour et al, Koike et al and Furukawa et al teach electron beam irradiation of said p-type layer to produce conductive semiconductors with low resistivities with hole densities of greater than  $1 \times 10^{17}/\text{cm}^3$ . This reads on applicant's

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limitation of treating a surface of said acceptor-doped layer to increase hole density to be greater than  $3 \times 10^{15} \text{ cm}^{-3}$ .

Referring to claim 13 and 43, the combination of Bour et al, Koike et al and Furukawa et al teaches electron rays were uniformly irradiated into the p-layer using a reflective electron beam, this reads on applicant's limitation of exposing said surface to electromagnetic radiation.

Referring to claim 14 and 44, the combination of Bour et al, Koike et al and Furukawa et al does not teach growing an acceptor doped layer results in acceptor impurities in said acceptor-doped layer having greater than 90% passivation prior to said cool down process. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of the combination of Bour et al, Koike et al and Furukawa et al by attempting to optimize same by routine experimentation.

Referring to claim 15-16 and 45-46, the combination of Bour et al, Koike et al and Furukawa et al teach three p-layers of Mg-doped  $\text{Al}_{x1}\text{Ga}_{1-x1}\text{N}$  p-layer (61) which acts as a clad layer having a hole concentrations of  $5 \times 10^{17}/\text{cm}^3$ ,  $5 \times 10^{17}/\text{cm}^3$  and  $2 \times 10^{17}/\text{cm}^3$  and an Mg concentrations of  $1 \times 10^{20}/\text{cm}^3$ ,  $1 \times 10^{20}/\text{cm}^3$  and  $2 \times 10^{20}/\text{cm}^3$ . This reads on applicant's limitation of a hole density greater than  $3 \times 10^{16} \text{ cm}^{-3}$  and having a density of acceptor impurities greater than  $5 \times 10^{18} \text{ cm}^{-3}$ .

Referring to claim 18 and 48, the combination of Bour et al, Koike et al and Furukawa et al does not teach the annealing is carried out at a temperature below  $400^\circ\text{C}$ . It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Bour and Koike by attempting to optimize same by routine experimentation.

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Referring to claim 19 and 49, the combination of Bour et al, Koike et al and Furukawa et al teach all of the limitations of claim 19, except an ex-situ anneal. The combination of Bour and Koike teach ex-situ post-growth anneals have become a common procedure for laser diode processing. It would have been obvious to a person of ordinary skill in the art at the time of the invention to perform the annealing process ex-situ because it allow the reaction chamber to be used to for the growth of more p-type GaN.

Referring to claim 20 and 50, the combination of Bour et al, Koike et al and Furukawa et al teach the anneal process is a quasi-in-situ anneal where the reactor is brought to room temperature prior to annealing, this reads on applicant's limitation of annealing is carried out after said cool-down process prior to any further processing of said p-type layer.

Referring to claim 21 and 51, the combination of Bour et al, Koike et al and Furukawa et al teach a device (40) processed into an operable laser, this reads on applicant's limitation of forming a light emitting diode.

Referring to claim 22 and 52, the combination of Bour et al, Koike et al and Furukawa et al teach a sapphire substrate upon which is grown a n-type GaN, doped with Si followed by the growth of an active region and is followed by a p-type GaN layer doped with Mg.

Referring to claim 23 and 53, the combination of Bour et al, Koike et al and Furukawa et al teaches three p-layers of Mg-doped  $\text{Al}_{x1}\text{Ga}_{1-x1}\text{N}$  forms a p-layer (61).

3. Claims 6, 9, 11, 36, 39 and 41 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bour et al. (US 5,926,726) in view of Koike et al. (US 5,811,319) and Furukawa et al (US

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6,017,807) as applied to claim 1, 3-5, 12-30, 31-35 and 42-60 above, and further in view of Takatani (US 6,100,174).

The combination of Bour et al, Furukawa et al and Koike et al teach all of the limitations of claim 6, except chemically etching said surface.

In a method of producing GaN group compound semiconductors, Takatani teaches a p-GaN layer epitaxially grown on a sapphire substrate, with about  $10^{19} \text{ cm}^{-3}$  of Mg added thereto for providing a carrier density of about  $1.5 \times 10^{17} \text{ cm}^{-3}$ , where carrier density reads on applicant's term of hole density. Takatani also teaches subjecting the surface of the p-GaN layer to ultrasonic cleaning in acetone and ethanol, thereby removing the oil present thereon and then immersing in an etchant containing HCl and deionized water for about 3 minutes, thereby removing the adsorbed oxide and then the substrate is immersed in an etchant containing HF and deionized water for about 3 minutes thereby removing impurities adhering to the surface, this reads on applicant's limitation of chemically etching. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the invention taught by the combination of Bour, Furukawa et al and Koike with Takatani's etching because it would have removed impurities and adsorbed oxygen from the substrate.

Referring to claim 9 and 39, Takatani teaches immersing a p-GaN substrate in an etchant containing HCl and deionized water for about 3 minutes, thereby removing the adsorbed oxide and then the substrate is immersed in an etchant containing HF and deionized water for about 3 minutes thereby removing impurities adhering to the surface. This reads on applicant's limitation of chemically cleaning said surface.

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Referring to claim 11 and 41, the combination of Bour et al, Furukawa et al and Koike et al teaches all of the limitations of claim 11, except ultrasonically cleaning said surface. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the invention taught by the combination of Bour et al, Furukawa et al and Koike et al with Takatani's ultrasonic cleaning because it would have removed the oil present on the surface of the substrate, which is detrimental to the surface.

4. Claim 10 and 50 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bour et al. (US 5,926,726) in view of Koike et al. (US 5,811,319), Furukawa et al (US 6,017,807) and Takatani (US 6,100,174) as applied to claims 6, 9, 11, 36, 39 and 41 above, and further in view of Peng et al. (US 5,895,223).

The combination of Bour et al, Koike et al, Furukawa et al and Takatani teach all of the limitations of claim 10, except the cleaning of said surface comprises cleaning in a solution of KOH, NaOH or NH<sub>4</sub>OH.

In a method of etching nitride, Peng et al teaches dipping a nitride chip in an electrolysis liquid and emitting a UV light with a wavelength of 254 nm to illuminate the nitride chip (col 3, ln 40-46), where the electrolysis liquid can be one of KOH as the nitride chip is GaN. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Bour et al, Koike et al, Furukawa et al and Takatani with Peng's because the etching method of Peng offers a finer roughness for an etching surface (col 4, ln 20-24).

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5. Claim 13 and 43 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bour et al. (US 5,926,726) in view of Koike et al. (US 5,811,319) and Furukawa et al (US 6,017,807) as applied to claims 1, 3-5, 12-30, 31-35 and 42-60 above, and further in view of Peng et al. (US 5,895,223).

The combination of Bour et al, Furukawa et al and Koike et al teach all of the limitations of claim 13, expect exposing said surface to electromagnetic radiation.

In a method of etching nitride, Peng et al teaches dipping a nitride chip in an electrolysis liquid and emitting a UV light with a wavelength of 254 nm to illuminate the nitride chip (col 3, ln 40-46), this reads on applicant's limitation of exposing to electromagnetic radiation, where the electrolysis liquid can be one of KOH as the nitride chip is GaN. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Bour et al, Koike et al and Furukawa et al with Peng's because the UV light would illuminate the nitride chip.

6. Claim 7-8 and 37-38 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bour et al. (US 5,926,726) in view of Koike et al. (US 5,811,319) and Furukawa et al (US 6,017,807) as applied to claims 1, 3-5, 12-30, 31-35 and 42-60 above, and further in view of Nitta et al (US 5,789,265).

The combination of Bour et al, Furukawa et al and Koike et al teach all of the limitations of claim 7, expect plasma etching said surface.

In a method of manufacturing a blue light emitting diode, Nitta et al. teaches a dry etching method for GaN based semiconductor compounds can be achieved by the plasma etching

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using  $\text{BCl}_3$  and  $\text{Cl}_2$ , where said GaN based semiconductor comprises p-type  $\text{In}_x\text{Ga}_{1-x}\text{N}$  (col 4, ln 41-55). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Bour et al, Furukawa et al and Koike et al with Nitta et al because etching rate can be increased and productivity enhanced.

Referring to claim 8, Nitta et al. teaches a dry etching method for GaN based semiconductor compounds, this reads on applicant's limitation of plasma cleaning said surface.

### *Response to Arguments*

7. Applicant's arguments filed 5/22/2003 have been fully considered but they are not persuasive.

The 112 first paragraph rejections have been withdrawn.

Applicant's argument that it would not have been obvious to combine Furukawa with Bour has been noted but is not found persuasive. Applicant alleges Bour specifically teaches that it is undesirable to complete cool-down prior to performing an anneal because of high processing times and costs, therefore Bour cannot be combined with Furukawa, which teaches a post cool down anneal. Bour does teach a process that does not require a post growth acceptor activation process, note column 9, lines 1-3, as suggest by applicant, which would reduce processing costs. Bour also recognizes post growth anneals after reactor cool down are common procedure, note column 2, lines 60-65. Furukawa teaches the activation yield of a p-type impurity can be improved by a simple process by annealing at more than  $400^\circ\text{C}$  in an inert atmosphere, note column 2, line 60 to column 3, line 10. Bour teaches a process without a post growth anneal to reduce cost and Furukawa teaches a post growth anneal to improve the activation yield of a p-

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type impurity. Although, the processing cost would increase because of a post growth anneal; a person of ordinary skill in that art at the time of the invention would be motivated to perform a post growth anneal to improve the activation yield. Economics are a concern in all processes; however obtaining a superior product (increased activation yield) is a valid motivation for increasing processing costs.

Applicant's argument that even if the post cool down anneal is performed in situ, a person of skill in the art would still expect to encounter high processing times and costs and potential contamination is noted but is not found persuasive. The potential contamination is a result of ex-situ processing, therefore would be avoided by using in-situ annealing. The high processing times and cost are drawbacks to a post growth annealing, however the improved activation yield is motivation to modify the process taught by Bour. Furthermore, Bour teaches no post growth acceptor activation is **necessary** in column 9, lines 1-3, therefore Bour is open to the common procedure of applying a post growth anneal to activate acceptors.

### *Conclusion*

8. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire **THREE MONTHS** from the mailing date of this action. In the event a first reply is filed within **TWO MONTHS** of the mailing date of this final action and the advisory action is not mailed until after the end of the **THREE-MONTH** shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37

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CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

9. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Matthew J Song whose telephone number is 703-305-4953. The examiner can normally be reached on M-F 9:00-5:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Benjamin L Utech can be reached on 703-308-3868. The fax phone numbers for the organization where this application or proceeding is assigned are 703-872-9310 for regular communications and 703-872-9311 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0661.

Matthew J Song  
Examiner  
Art Unit 1765

MJS  
July 31, 2003

NADINE G. NORTON  
PRIMARY EXAMINER  
*Nadine Norton*